

# Articles

## Angiographic Yield in Penetrating Extremity Trauma

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Indications for angiography in the evaluation of penetrating extremity trauma remain controversial. Our experience was reviewed to determine the yield of angiography in penetrating extremity trauma and to correlate clinical findings with angiographic results. During an 81-month period from 1983 through 1989, 284 extremity arteriograms were carried out in 268 patients. The angiographic yield in patients with abnormal clinical findings was 51%. The angiographic yield in patients when proximity of the injury to major vessels was the only indication was 6% (7% with gunshot wounds and 0% with stab wounds). Neurologic deficit alone as an indication for angiography accounted for 55% of the angiograms interpreted as "negative" and none of those interpreted as "positive." We conclude that the use of angiography in patients with gunshot wounds to the extremity with "proximity injuries" to major vessels should continue, its use is not warranted in extremity stab wounds when proximity is the sole indication, and abnormal neurologic findings in the absence of other findings are a poor predictor of vascular injury.

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Angiography is used with increasing frequency in the evaluation of suspected vascular injuries from penetrating trauma. The routine use of angiography in the absence of specific clinical findings has been seriously questioned in recent reports, which recommended limiting its use to selected patients as safe and cost-effective.<sup>1-8</sup> Specific clinical findings such as pulse deficit, bruit, expanding hematoma, arterial bleeding, and neurologic deficit are widely accepted indications for angiography in patients with penetrating extremity trauma.<sup>9-11</sup> Controversy concerning the aggressive use of angiography continues, however, when an injury's proximity to major vessels is the only indication.<sup>11-13</sup> The experience at the Highland General Hospital Trauma Center, Oakland, California, was retrospectively reviewed to determine the yield of angiography in penetrating extremity trauma and to correlate clinical findings with angiography results.

### Patients and Methods

The records of patients admitted to the Highland General Hospital Trauma Center who underwent angiography because of penetrating extremity injuries were retrospectively reviewed for the period beginning January 1, 1983, and ending September 1, 1989. All patients were evaluated initially by the chief surgical resident or the attending surgeon. Excluded from this review were patients with definite vascular injuries who were operated on based solely on clinical indications and patients with concomitant injuries requiring emergency operations. The decision for angiography was made by attending surgeons or the chief surgical resident after consultation with the attending surgeon. Conventional arteriography was done by interventional radiologists using standard catheter techniques with serial filming. Results were jointly interpreted by the radiologist and the attending surgeon.\* Decisions for surgical exploration of these vascular

injuries were based on a combination of clinical and angiographic findings.

The clinical findings used in the decision-making process were diminished or absent distal pulses, a palpable thrill or bruit, cold or cyanotic extremities, a neurologic deficit, arterial bleeding, or an expanding hematoma.<sup>9-11</sup> The angiographic findings interpreted as "positive" include occlusion of a major vessel, an arteriovenous fistula, an intimal injury, pseudoaneurysm, the extravasation of contrast material, and spasm. Muscular branch lacerations were not considered positive angiographic findings. All operative reports were reviewed, and follow-up information was recorded from outpatient records.

### Results

During this 81-month period, a total of 284 angiographic procedures were carried out in 268 patients for penetrating extremity trauma with vascular proximity. Their ages ranged from 15 to 59 years, with a male to female ratio of 12:1 (247 men and 21 women). Most of the injuries were gunshot wounds (79%), and 21% were stab wounds. Two thirds (142 of 213) of the gunshot wounds involved the lower limbs, and a third were in the upper extremities. Of the 55 stab wounds encountered, 32 (58%) and 23 (42%) involved the upper and lower extremity, respectively. Upper extremity angiographic procedures were done in 39% of the patients and 61% in the lower extremities. Of all studies, 229 (81%) were performed for gunshot wounds and 55 (19%) for stab wounds. Of the 284 arteriograms, the results of 57 (20%) were positive based on the aforementioned criteria; 44 of 229 (19%) in gunshot wounds, and 13 of 55 (24%) in stab wounds. A total of 194 angiograms (68%) were done because of proximity of the injury to major blood vessels (70% of the gunshot wounds and 62% of the stab wounds).

The angiography yield was 6% (11 of 194) when penetrating extremity trauma with proximity was the only indication;

\*Arthur T. Gronner, MD, of the Radiology Department provided assistance.

in the gunshot and stab wound groups, the yield was 7% (11 of 160) and 0% (0 of 34 [95% confidence interval, 0% to 10%]), respectively.

Of the 11 patients with positive angiograms, 5 had potentially serious injuries, 3 of which were confirmed during an operation. These included a superficial femoral artery occlusion requiring vein grafting, a femoral arteriovenous fistula managed by resection and a polytetrafluoroethylene graft replacement, a superficial femoral vein injury treated by ligation, partial occlusion of the right radial artery with good collateral flow, and thrombosis of the anterior tibial artery with intact posterior tibial and peroneal arteries. The last two patients were observed clinically and subsequently discharged. The remaining six patients with angiograms showing spasm were observed and discharged without additional clinical signs or symptoms developing. All nonoperated patients had an uneventful hospital course (Table 1).

One angiogram falsely interpreted as "negative" occurred in a patient with a gunshot wound to the right thigh who later presented with a pseudoaneurysm of the superficial femoral artery that was successfully repaired. He suffered another gunshot wound to the same extremity; angiography revealed patent vessels and no abnormalities.

A definition of yield determinations is given in Table 2. The criteria for positive clinical findings were based on previous reports.<sup>9-11</sup> To determine the importance of each clinical finding, the predominant clinical finding in each patient was correlated with angiographic results. There were 24 negative angiograms when only a neurologic deficit was the indication for angiography. This group represented 55% of all negative angiograms.

## Discussion

The role of angiography in the evaluation of penetrating trauma to the extremities remains controversial, particularly in patients who have no indicative clinical findings other than proximity of the injury to major vessels.<sup>11-13</sup> The published yield of positive angiograms in this set of patients (proximity) from recent studies varies between 6% and 21%.<sup>1,4-7,13</sup> The positive angiography yield at the Highland General Hospital Trauma Center for this group of patients was 6%. All positive angiograms were in the group sustaining gunshot wounds, and none were observed in the stab wound group. The yield is actually 7% in patients with gunshot wounds and 0% in patients with stab wounds.

Of the patients in this series, 68% underwent angiography because of proximity of injury to blood vessels—70% of the patients with gunshot wounds and 62% of those with stab wounds. These figures are consistent with those of previous

TABLE 2.—Angiography Versus Clinical Findings (n = 284)

Physical Findings	Angiography	Gunshot Wounds, Patients, No.	Stab Wounds, Patients, No.
Abnormal.....	Positive	33	13
Abnormal.....	Negative	36	8
Normal.....	Positive	11	0
Normal.....	Negative	149	34

reports.<sup>5,6,10</sup> The overall yield of 6% is also in agreement with the 6% to 21% published yield.<sup>11</sup>

Only three patients without clinical findings were operated on based on angiographic findings. (Management change as a consequence of angiography in patients with no clinical findings is 1.5%, or 3 of 194 patients.) It is easy to argue that patient management is rarely changed by doing angiograms when no clinical finding is present. Unfortunately, the follow-up in this group of patients is often unreliable. The outcome of patients with positive angiography, but not operated on, based on clinical judgment remains unknown. It is safer to manage a known injury selectively based on clinical judgment than to be later surprised by a potentially dangerous occult injury.

The mechanisms of vascular injury due to gunshot and stab wounds are somewhat different. Stab wounds usually cause direct trauma to the vascular structure with minimal surrounding tissue damage. Bullets can be of high velocity and energy, and, in addition to the resulting direct trauma, the temporary cavity that follows can cause considerable damage at a distance greater than the diameter of the missile tract, resulting in vascular injury away from the wound site with accompanying surrounding tissue damage.<sup>14,15</sup>

The use of angiography in patients with no clinical findings must be balanced against the complications of angiography itself. No patient in this series had a major complication from angiography. The overall major complication rate from angiographic procedures performed on trauma patients during this period was 0.6%, consistent with the published results of less than 1%.<sup>16</sup> Although the chance of major complication is small, serious potential risks certainly exist.

We concur that the use of angiography in patients with gunshot wounds to the extremity with major vessel proximity is appropriate because of the 7% yield. The greater potential for distant vascular injuries from the destructive force of missiles outweighs the risks of complications. In patients with stab wounds to extremities and absent clinical findings, angiography is not warranted. This confirms previous recommendations by Hartling and co-workers.<sup>11</sup>

The yield of angiography in patients with definite clinical findings was 51% (46 of 90) for both groups: 48% (33 of 69) in the gunshot wound group and 62% (13 of 21) in the stab wound group. Physical examination, in our experience, is sensitive in identifying vascular injuries, as indicated by other reports.<sup>6,7,10,11</sup>

The correlation between clinical findings and angiographic results showed that the most reliable signs were a pulse deficit, active bleeding, or an expanding hematoma. These accounted for 63% of the positive angiograms and only 18% of the negative angiograms. A neurologic deficit alone as an indication accounted for more than half (55%) of the negative angiograms; there were no positive angiograms in this group. This is in agreement with the findings of O'Gorman and associates<sup>5</sup> but differs from other reports that

TABLE 1.—Location of Positive Angiographic Findings With Normal Clinical Findings (False-Negative)

Angiographic Finding	Patients, No.	Treatment
Superior femoral artery occlusion .	1	Vein graft
Superior femoral AV fistula . . . . .	1	Resection, Gortex graft
Superior femoral vein laceration . .	1	Ligation
Contusion of radial artery . . . . .	1	Observed and discharged
Laceration of anterior tibial artery	1	Observed and discharged
Spasm of popliteal artery . . . . .	2	Observed and discharged
Spasm of deep femoral artery . . . . .	2	Observed and discharged
Spasm of brachial artery . . . . .	2	Observed and discharged

AV = arteriovenous

showed that a neurologic deficit alone as an indication accounted for 11% to 42% of positive angiograms.<sup>6,9,10</sup> The number of patients with an isolated neurologic deficit as an indication for angiography in these series was small. The total number in all three series consisted of 9 positive angiograms in 30 patients with a neurologic deficit alone as the indication for angiography. Clearly a neurologic deficit is a vague and broad term. It can mean a variety of symptoms ranging from numbness or tingling to paralysis. Paralysis is a well-known sign of acute arterial vascular insufficiency.<sup>17</sup> A number of reasons for paresthesia may exist in an extremity distal to a penetrating injury, however. Neurologic deficit was defined in only one series as simply motor or sensory loss.<sup>9</sup>

Our experience supports the continued use of angiography in extremity gunshot wounds with proximity to a major blood vessel. The use of angiography for stab wounds based solely on proximity to vessels should be abandoned. Abnormal neurologic findings in the absence of other findings are a poor predictor of vascular injury. Patients managed by physical findings alone and those with injuries managed by observation need to be observed carefully after an injury because the long-term natural history of these injuries is unknown.

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